AD-A070 031   COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH   F/G 13/2
FREEZING PROBLEMS ASSOCIATED WITH SPRAY IRRIGATION OF WASTEWATE--ETC(U)
MAY 79 J R BOUZOUN

UNCLASSIFIED   CRREL-SR-79-12   NL

1 OF 1
AD
A070031

END
DATE
FILMED
7-79
DDC

Special Report 79-12

May 1979

LEVEL II

AD A070031

~~F~~REEZING PROBLEMS ASSOCIATED WITH SPRAY IRRIGATION OF WASTEWATER DURING THE WINTER

...n R. Bouzoun

Prepared for
DIRECTORATE OF MILITARY PROGRAMS
OFFICE, CHIEF OF ENGINEERS
By
UNITED STATES ARMY
CORPS OF ENGINEERS
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE, U.S.A.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
(9) Special Report 79-12

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
(6) FREEZING PROBLEMS ASSOCIATED WITH SPRAY IRRIGATION OF WASTEWATER DURING THE WINTER.

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
(10) John R. Bouzoun

8. CONTRACT OR GRANT NUMBER(s)

(16)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Cold Regions Research and
and Engineering Laboratory
Hanover, New Hampshire 03755

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
DA Project 4A762730AT42
(17) Task A3, Work Unit 019

11. CONTROLLING OFFICE NAME AND ADDRESS
Directorate of Military Programs
Office, Chief of Engineers
Washington, DC 20314

12. REPORT DATE
(11) May 1979

13. NUMBER OF PAGES
12

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
(12) 17p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

(14) CRREL-SR-79-12

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Discharge	Sewage	Waste water
Disposal	Sewage disposal	Water treatment
Effluents	Sewage treatment	
Facilities	Waste disposal	
Land areas	Waste treatment	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

During the winters of 1975-76, 1976-77 and 1977-78 biologically treated wastewater was applied to land in West Dover, Vermont. The wastewater was applied using the spray irrigation method at ambient temperatures as low as 0°F. During the first winter, freezing was a major problem. Modified spray nozzles that were less susceptible to freezing were installed at both the low points and high points of the aboveground spray laterals. During the second and third winters, ice buildup along the spray laterals, particularly in the vicinity of the spray nozzles, caused serious damage to the pipes. Many man-hours were

cont

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 037 100 LB

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract (cont'd)
required to continuously cut the ice from the laterals. As an experiment to alleviate the problem several 30- to 36-in. risers were installed at an angle of approximately 30° from the vertical on two of the spray laterals during the winter of 1977-78. They functioned well enough to warrant future installation on the entire system of spray laterals.

PREFACE

This report was prepared by John R. Bouzoun, Environmental Engineer, Civil Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. The study was funded under DA Project 4A762730AT42, Design, Construction and Operations Technology for Cold Regions, Task A3, Facilities Technology, Work Unit 019, Engineering Design and Management of Wastewater Land Treatment Systems in Cold Climates.

Special acknowledgment is due the Dufresne-Henry Engineering Corporation of North Springfield, Vermont, for their original investigation of the problems discussed in this report. Their reports on the subject served as the foundation for further research and subsequently this report.

The author expresses his appreciation to Wallace Bronson, plant operator of the North Branch Fire District No. 1 Sewage Treatment Facility, West Dover, Vermont, for his assistance in preparing this report. Technical reviewers of the manuscript were C. James Martel and Robert S. Sletten of CRREL.

The contents of this report are not to be used for advertising or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

SUMMARY

Because of stringent water quality control regulations enacted by the Vermont Water Resources Board in 1971 which, in essence, prohibited discharge of sewage effluent into upland streams, a land treatment facility was constructed in West Dover, Vermont, to treat wastewater. Since the average daily design flow for the facility was almost twice as high in winter as in summer (0.55 mgd vs 0.30 mgd) due to the influx of skiers to the area, the facility had to be able to operate efficiently throughout the winter.

The mode of treatment at West Dover consists of spraying biologically treated wastewater onto a forested knoll. Twelve spray laterals run parallel to each other, approximately 75 ft apart. They are suspended approximately 5-15 ft above the ground on posts and follow the contours of the hillside. Upward-spraying nozzles are spaced at 25- to 50-ft intervals along the laterals. Downward-spraying nozzles have been installed at the 66 low points to drain the laterals after spraying to prevent freezing.

During three winters of operation, spray nozzles were modified or replaced to allow spraying at ambient air temperatures as low as 0°F. Changes in operating procedures have also allowed more winter spraying. The operator experimented with risers on the laterals to direct the spray away from them, thereby minimizing the buildup of ice.

The main conclusion drawn from the studies conducted at West Dover is that spray irrigation is possible at ambient air temperatures as low as 0°F. However, steps must be taken to ensure that spray nozzles and distribution laterals are kept from freezing. Specific suggestions on how to minimize problems of freezing are found at the end of the report.

INTRODUCTION

Land treatment of wastewater may be technically or economically desirable in areas which experience moderate to severe winters. To minimize storage, it may be necessary to apply wastewater to the land in subfreezing conditions. This report is an assessment of the problems associated with applying wastewater by spray irrigation during the winter in a cold climate.

The system discussed in this report is the wastewater treatment facility of the North Branch Fire District Number 1, located in West Dover, Vermont (Fig. 1, 2, 3). The general design and operating characteristics of this site have been previously reported (Cassel 1977, Bouzoun 1977). The system is essentially a spray irrigation system and treats wastewater from several nearby ski resorts (motels, lodges, restaurants). The winter design flow is nearly double the design flow for other seasons of the year. This plus the fact that the total storage capacity of the system in winter is only 34 days makes spraying of the wastewater during the winter a necessity.

Twelve spray laterals run parallel to each other in a north-south direction following the undulating contours of the spray site. They are 75 ft apart and 5 to 15 ft above the ground. Each consists of 2- and 3-in. galvanized steel pipe insulated with a jacket of PVC pipe. Vegetation has been cleared for 5 to 10 ft on either side of each lateral. Figure 4 shows a spray lateral during March 1978. Figure 5 is a cross section of a typical lateral. There are 66 low points in the system where, originally, 1/2-in. spray nozzles were installed. These nozzles spray downwards to rapidly drain the laterals after each spray cycle (Fig. 6). Originally, Buckner Turf King rotary sprinklers were installed every 50 ft along the spray laterals, except at the low points. Additional information on these nozzles and their operational characteristics is presented below.

OPERATION

As shown in Figure 3, there are three spray pumps, each of which supplies a separate header which in turn feeds four spray laterals. At any given time, each pump can pump to one of its four laterals. The flow to each spray lateral is regulated by a pneumatic Camflex valve. There are two methods of operating the spray system -- automatic or manual. During automatic operation a cam/timer system is used to program the desired timing and selection of spray laterals. After one spray lateral has operated for a specified length of time, it automatically shuts off and the next one begins. During manual operation the operator turns on the spray pump and adjusts the Camflex valve of the selected spray lateral. It will spray until the operator shuts it off.

SPRAY NOZZLES

There are 66 downward-spraying nozzles and, depending on the season, between 300 and 670 high point nozzles on the laterals. This section of the report discusses the problems that have occurred with these nozzles under winter conditions, and their solutions.

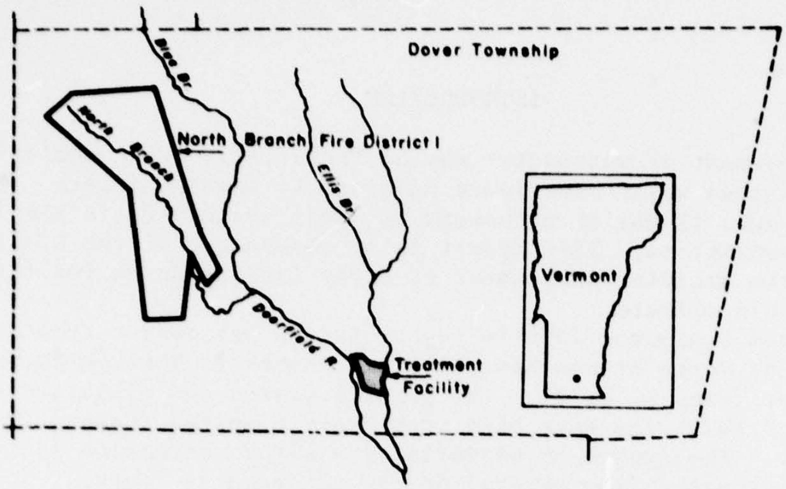


Figure 1. General location map.

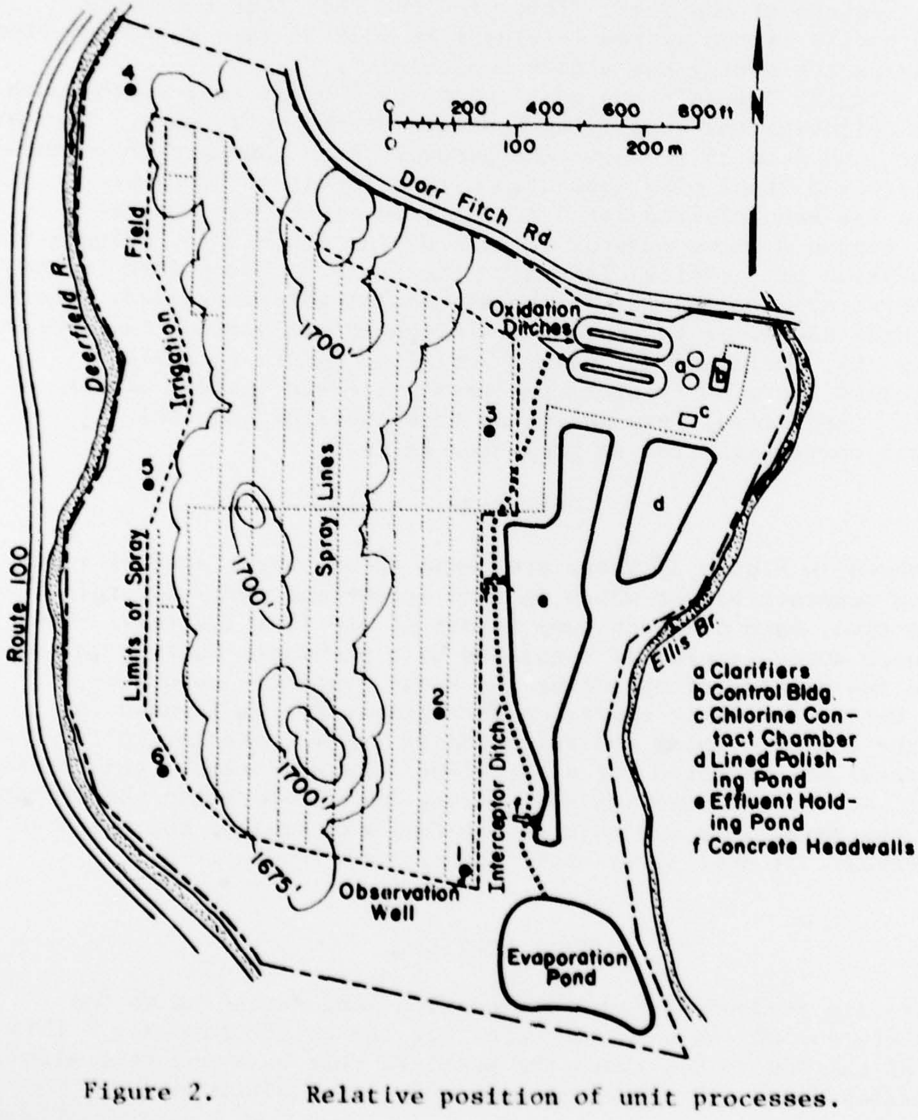


Figure 2. Relative position of unit processes.

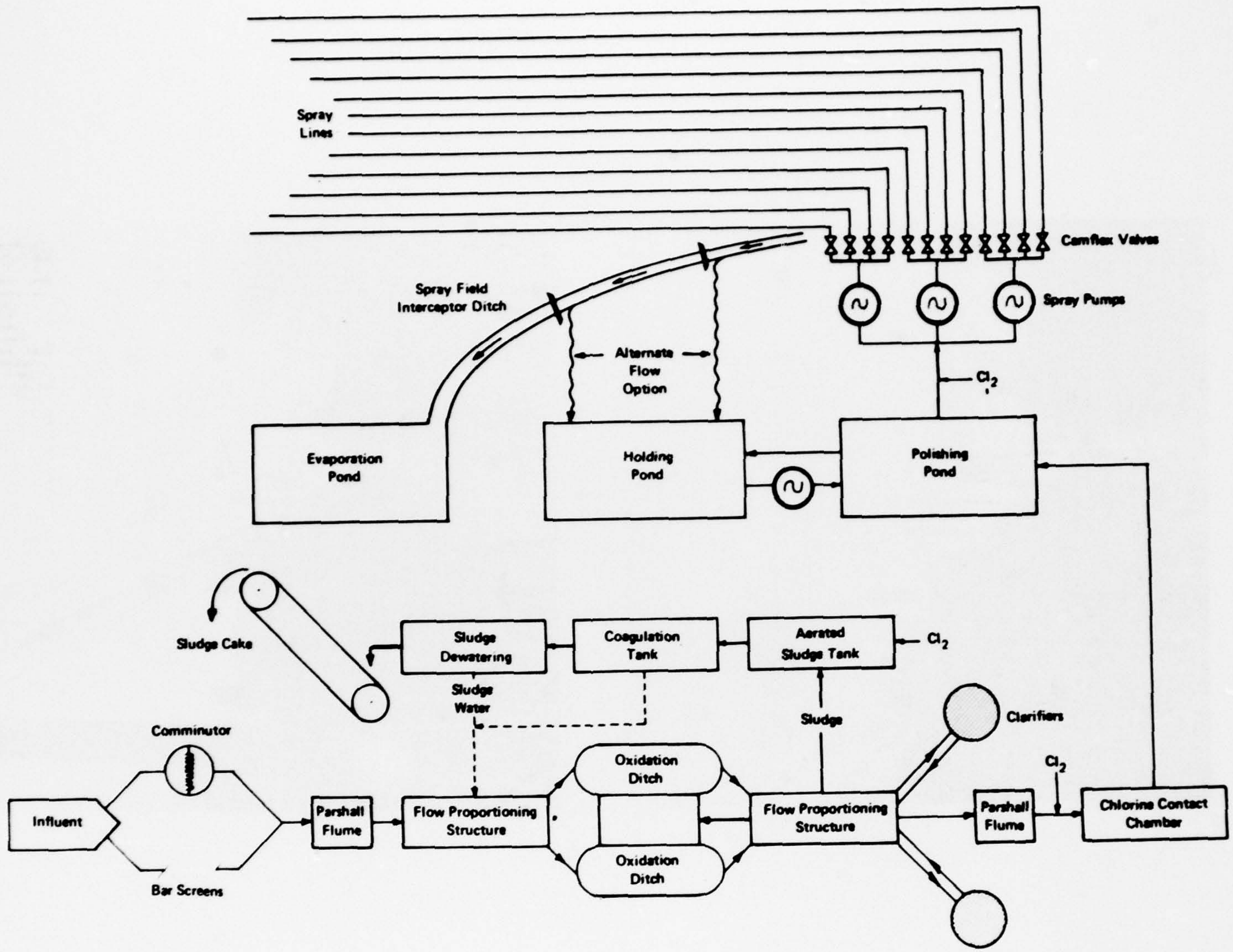


Figure 3. Hydraulic schematic.

Figure 4. Spray lateral.

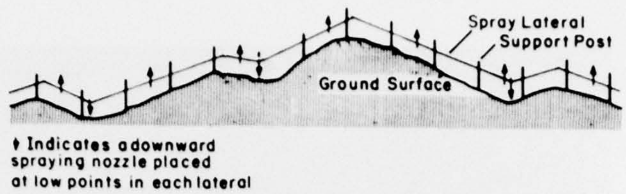


Figure 5. Cross section of typical spray lateral.

Downward-Spraying Nozzles

Originally Parasol 1/2 E40 nozzles manufactured by Spraying Systems Co. were installed at the 66 low points along the spray laterals. Their purpose was to drain the low sections of the spray laterals after completion of a spray cycle. During the first winter of operation (1975-76) it was found that the Parasol nozzles would effectively drain most of the wastewater within 1 hour of the completion of a spray cycle. However, a small quantity of wastewater would continue to drip from these nozzles for several hours. This wastewater had a temperature of about 40°F when it was within the lateral, and would freeze at ambient air temperatures as high as 27°F when it dripped out. During the next spraying cycle the nozzles would remain frozen and would not spray. The frozen nozzles became a problem at the end of a spray cycle because there was no way for the wastewater to drain from the low points in the laterals. The laterals were then susceptible to damage caused by the progressive freezing of the wastewater left in them.

Because of these problems, the engineering firm of Dufresne-Henry of Springfield, Vermont, who had designed the system, conducted a special study (Dufresne-Henry 1976a). They evaluated several alternatives or partial solutions to the problem. Many alternatives were eliminated after an initial screening indicated they would be too expensive. Others were eliminated after field testing showed they did not alleviate the problem.

After several tests Dufresne-Henry recommended installation of modified Fulljet 3/4 HH6W nozzles, also manufactured by Spraying Systems Co. This Fulljet nozzle contains two vanes, each of which can be isolated from the other. One of the vanes is fed through the body of the nozzle itself, and the other is fed through a 3/8-in. brass tube which extends upward out of the base of the spray nozzle (Fig. 7).

When the spray lateral is shut off, the wastewater drains by gravity through both vanes until the liquid level in the lateral reaches the top of the copper tube. At this point, liquid stops flowing through the vane fed by the tube. The other vane continues to drain. Because the liquid quickly passes by the entrance to the tube, the weeping action described previously does not occur and the vane remains open. The other vane is subject to weeping and may freeze shut during the final stages of drainage. However, when the lateral is brought back on line, liquid passes through the open vane and heat from the flowing liquid transfers through the brass partition separating the two vanes and quickly thaws the other vane, restoring the nozzle to normal operation (see Fig. 8).

Figure 6. Downward-spraying nozzle.

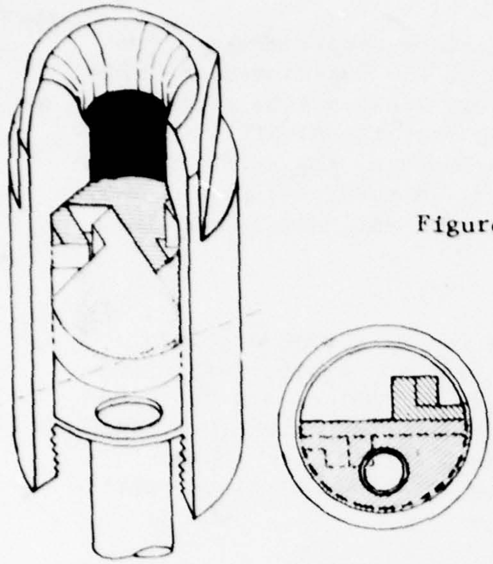
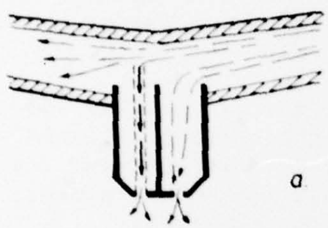
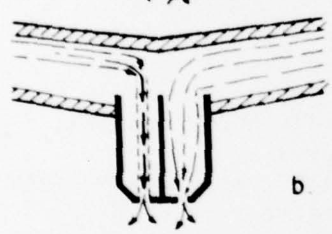


Figure 7. Modified Fulljet 3/4 HH6W nozzle.



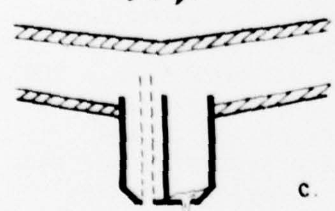
a

Spraying.



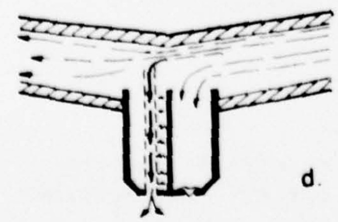
b

Draining. Brass tube in left half drains quickly, until liquid level is below its top. Then only right half continues to drain.



c

Line drained. Small amount of ice has formed to block right half of nozzle. Brass tube left half is open and ready for next spray cycle.



d

Next spray cycle. Water initially sprays through the brass tube on the left side. The heat from the liquid melts the ice plug blocking the right half of the nozzle and spraying resumes in the normal manner as shown in a.

Figure 8. Operation of modified Fulljet 3/4 HH6W nozzle.

After installation of these modified nozzles, spraying was accomplished at ambient air temperatures as low as 0°F. Dufresne-Henry also recommended that automatic alternating of spray lines not be practiced during the winter months in order to minimize operational difficulties. Instead, they recommended that continuous spraying of the spray lines be accomplished over the course of the spray day. A spray day may be only a few hours, during which the allowable amount of effluent is applied.

Upward-Spraying Nozzles

Originally, about 300 Buckner Turf King rotary sprinklers were installed as the high point nozzles for the system. Again, during the winter of 1975-76 problems occurred with these sprinklers and Dufresne-Henry conducted a special study to identify and correct them (Dufresne-Henry 1976b). They determined that the Buckner nozzles were unsatisfactory for use during winter operations because they were susceptible to:

1. Freezing damage.
2. Plugging due to freezing.
3. Excessive maintenance because the nozzle had moving parts and because it had to be kept perfectly level.

They also noted that the spray diameter of the Buckner nozzles (55-65 ft) was significantly greater than the width of the corridor cleared along each spray lateral (10-20 ft). This resulted in a significant ice buildup on many of the trees along the spray laterals during the winter. In an effort to find a suitable winter replacement for the Buckner nozzles, Dufresne-Henry reviewed the available literature and selected several nozzles for on-site testing. As a result of their testing program they recommended that the Buckner nozzles, located every 50 ft along the spray laterals, be replaced with Fulljet 1/4 HH14W nozzles, manufactured by Spraying Systems Co., at 25-ft intervals.

The Fulljet nozzles were recommended because their application rate (0.275 in./hr) was very close to the design application rate of 0.25 in./hr. By placing the Fulljet nozzles at 25-ft intervals along each spray lateral, more than 600 of them would have been required as compared with approximately 300 Buckner nozzles. This was more than a 200% increase, which offset the lower capacity of the Fulljet nozzles (6.20 gpm for the Buckner versus 2.75 gpm for the Fulljet, or 44%). The capacity of the new system with Fulljet nozzles was essentially the same as with the Buckner nozzles. As with the downward-spraying nozzles, there have been very few problems associated with the new nozzles during the winter.

SNOW AND ICE BUILDUP

After the problems with the nozzles had been alleviated and the system operated throughout the winters of 1976-77 and 1977-78, problems began to develop due to snow and ice buildup. This section discusses these problems and the method used by the operator to alleviate them.

Figure 9. Snow and ice buildup near spray nozzle.

As spraying continued throughout the winter, large amounts of snow and ice formed under the spray laterals, particularly within the spray circle of the nozzles. During the winter of 1977-78 only laterals 5 through 9 were used. Typically, the operator would spray two of these laterals all day. On the next spray day he would spray two different laterals while he attempted to remove the ice that had built up during the previous day. Although the operator worked hard to remove the ice from the laterals a large amount of it did accumulate around the spray nozzles (Fig. 9). As these mounds continued to build, their weight actually caused sags in the spray laterals (Fig. 10). Because there was no way of draining them, these low points were very susceptible to freezing and bursting, or plugging of the lateral.

To minimize the buildup of ice and snow on the laterals, the operator, acting on the recommendations of Dufresne-Henry (Dufresne-Henry 1977), removed the spray nozzle from the lateral and placed it on top of a copper riser about 30-36 in. long. Angling the riser approximately 20-30 degrees from the vertical directed the spray away from the lateral. Figure 11 shows two of these experimental risers on spray laterals. The results were excellent and the operator intends to install these risers along the entire length of several laterals. Also, he plans to have all the risers on one lateral lean towards the west and those on the next lateral towards the east. Then he can select laterals where the spray will not be blown back on them by the wind.

Figure 10.   Sags in spray lateral.

Figure 11. Experimental risers on spray laterals.

RECOMMENDATIONS

As a result of three winters' experience in spraying wastewater at ambient air temperatures as low as 0°F at West Dover, Vermont, the author recommends that the following be considered when designing a wastewater spray irrigation system to be used during the winter in cold climates.

1. Where possible, distribution laterals should be buried deep enough to protect them against freezing, and vertical risers should be insulated.
2. The risers should be high enough above the ground to ensure that they will not be buried by either naturally occurring snow or the snow and ice formed by spraying.
3. The risers should be reinforced to provide stability against the weight of ice and snow that may adhere to them.
4. Provisions should be made to back-drain both the risers and the distribution laterals after a spray cycle to prevent freezing.
5. If it is too expensive to bury the laterals and they are suspended above the ground, as at West Dover, the use of Fulljet nozzles, modified as discussed previously, at the low points in the line should be considered.
6. The use of risers at enough of an angle to ensure that the spray does not freeze on the laterals should be considered when the laterals are above the ground.
7. The ability to manually start and stop spraying specific laterals as compared to spraying and draining many laterals several times per day should be built into the system.
8. If the spray nozzle diameter is fixed by the wastewater application rate allowed at the site, and if the system is being built in a forested area, corridors cut for the spray laterals should be wide enough so that spray does not freeze to the trees.

LITERATURE CITED

Cassel, E. Alan (1977) Existing information collection on the North Branch Fire District No. 1 wastewater treatment facility. Prepared for the U.S. Army Cold Regions Research and Engineering Laboratory by Vermont Water Resources Research Center.

Bouzoun, John R. (1977) Land treatment of wastewater at West Dover, Vermont. CRREL Special Report 77-33.

Dufresne-Henry Engineering Corporation (1976a) North Branch Fire District No. 1, West Dover, Vermont, Interim report on spray field alterations. April.

Dufresne-Henry Engineering Corporation (1976b) North Branch Fire District No. 1, West Dover, Vermont, Second interim report on spray field alterations. September.

Dufresne-Henry Engineering Corporation (1977) North Branch Fire District No. 1, West Dover, Vermont, Final report on spray field alterations (draft).